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(54) Fuel injector arrangement

(57) A fuel injector arrangement comprising a nozzle body provided with a first bore (11) within which a valve needle (12) is slidable, the needle being engageable with a first seating (11a) to control the flow of fuel from a delivery chamber (13) to an outlet opening. A control valve arrangement (26) is provided for controlling the supply of fuel to the delivery chamber (13). The control valve arrangement (26) includes a valve member (28) which is engageable with a second seating (46), the second seating (46) being moveable with the valve needle (12) to control the supply of fuel to the delivery chamber (13).

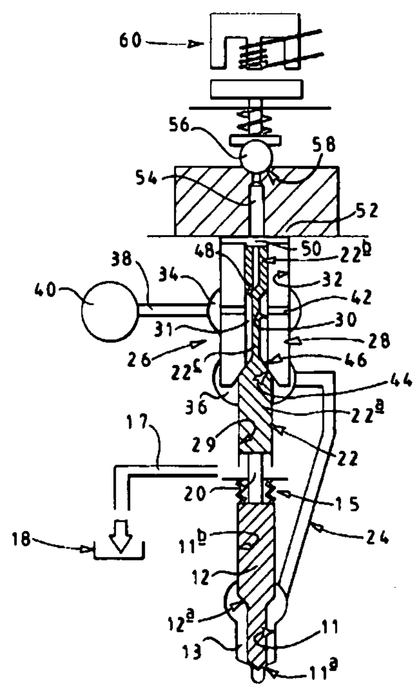

FIG 1

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Description

[0001] This invention relates to a fuel injector arrangement for use in delivering fuel under pressure to a combustion space of an internal combustion engine. The invention relates, in particular, to a fuel injector arrangement suitable for use in a fuel system of the common rail type.

[0002] In a known common rail fuel injector, a valve needle is engageable with a seating to control the delivery of fuel to a combustion space. The position of the needle is controlled by controlling the fuel pressure within a control chamber. In such an arrangement, in the event that the valve needle becomes stuck in a lifted position, fuel will be delivered continuously by the injector. Such a continuous discharge of fuel under pressure could cause a catastrophic failure of the engine and/or fuel system.

[0003] An alternative arrangement comprises a valve needle spring biased towards a seating, and a control valve controlling the supply of fuel to a delivery chamber of the injector. In such an arrangement, if the control valve sticks in an open position, fuel delivery will occur continuously and may result in failure as described hereinbefore. Additionally, it is difficult to inject small quantities of fuel with fuel injectors of this type as full movement of the control valve, and hence the valve needle away from the seating results in the injection of large fuel quantities. To achieve small quantities of fuel injection it is necessary to only partially lift the control valve away from the seating. However, it is difficult to achieve a consistent degree of partial lift of the control valve with this type of fuel injector.

[0004] It is also known to provide a "flow fuse" in the fuel flow path between the source of fuel at high pressure and the nozzle body of the fuel injector, the flow fuse acting to ensure that the supply of fuel to the nozzle body is terminated if the fuel flow becomes too high, for example due to a valve needle becoming stuck in an open position. However, flow fuses do not work well in situations where the valve needle becomes stuck in a partially open position.

[0005] European Patent Application No 00302079.9 describes a fuel injector arrangement in which a control valve controls the supply of fuel to a delivery chamber, the fuel injector including a valve needle which is engageable with a seating to control the flow of fuel from the delivery chamber to an outlet opening of the fuel injector. The control valve is actuated by controlling fuel pressure within a control chamber associated with the control valve. If the valve needle becomes stuck in an open position when it is required to cease fuel injection, fuel pressure within the control chamber forces the control valve closed so that fuel is no longer supplied to the delivery chamber. Thus, undesirable delivery of fuel is halted if the valve needle becomes stuck in an open position.

[0006] It is an object of the invention to provide an alternative type of fuel injector arrangement which also obviates or mitigates the disadvantages described hereinbefore.

[0007] According to the present invention there is provided a fuel injector arrangement comprising a nozzle body provided with a first bore within which a valve needle is slidable, the needle being engageable with a first seating to control the flow of fuel from a delivery chamber to an outlet opening, a control valve arrangement for controlling the supply of fuel to the delivery chamber, the control valve arrangement including a valve member which is engageable with a second seating which is moveable with the valve needle to control the supply of fuel to the delivery chamber.

[0008] Such an arrangement is advantageous in that continuous delivery of fuel requires both the valve needle to become stuck in a lifted position and the valve member to become stuck in an open position. The risk of continuous fuel delivery and the associated risk of damage to the engine and fuel system are thereby reduced. The need for a fuel flow fuse in the fuel flow path between a source of fuel at high pressure and the nozzle body is also removed.

[0009] The invention also provides the advantage that, when the valve member is seated against the second seating, the force acting on the valve needle to bias the needle against the first seating depends on the combined force applied by the valve member and a component which defines the second seating, when the valve member is lifted away from the second seating, the force acting on the valve needle is applied by only the component. Thus, the control valve arrangement can be operated more rapidly, thereby permitting termination or commencement of fuel injection to be achieved more rapidly.

[0010] Conveniently, a surface of at least one of the valve member and the component may be exposed to fuel pressure within a first control chamber. Preferably, fuel pressure within the first control chamber may be controlled by means of a further control valve arrangement to control the position occupied by the valve needle.

[0011] The component may comprise a piston member which defines the second seating with which the valve member is engageable to control fuel flow to the delivery chamber. In this case, movement of the piston member is accompanied by sliding movement of the valve needle within the bore of the nozzle body.

[0012] The piston member and the valve needle may be integrally formed, or may be separate parts, in which case the piston member and the valve needle may be interconnected by means of a load transmitting member. The piston member may be slidable within a further bore provided in the valve member. Alternatively, the valve member may be slidable within in additional bore provided in the piston member.

[0013] The fuel injector may include a second control chamber for fuel, fuel pressure within the second control

chamber acting on a surface associated with the valve member so as to oppose fuel pressure within the first control chamber acting on another surface associated with the valve member. By maintaining fuel pressure within the second control chamber at a reduced level, when a relatively high fuel pressure is established in the first control chamber, the difference in fuel pressure between the first and second control chambers causes the valve member to seat against the second seating rapidly, such that fuel delivery to the delivery chamber is ceased rapidly.

[0014] Conveniently, the piston member is provided with a blind bore, the valve member being slidable within the blind bore and the second control chamber being defined, in part, by the blind end of the bore.

[0015] In addition to providing a second control chamber, or alternatively, the first control chamber may be provided with biasing means, such as a compression spring, which serve to bias the valve member against the second seating.

[0016] The valve member may preferably be provided with a restricted passage through which fuel is supplied to the first control chamber, in use.

[0017] Alternatively, the piston member may be provided with a restricted passage through which fuel is supplied to the first control chamber, in use.

[0018] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view illustrating a fuel injector arrangement in accordance with an embodiment of the invention; and

Figures 2 to 4 are views similar to Figure 1 illustrating further embodiments.

[0019] Referring to Figure 1, the fuel injector includes a nozzle body (not shown) within which a blind bore 11 is formed, the bore 11 including an upper end region 11b. A valve needle 12 is slidable within the bore 11, the valve needle 12 including an enlarged diameter region, the diameter of which is substantially the same as the diameter of the bore region 11b such that sliding movement of the valve needle 12 is guided within the bore 11. The bore 11 defines, at its blind end, a seating 11a with which a tip portion of the valve needle 12 is engageable to control fuel delivery from a delivery chamber 13, defined by the bore 11 upstream of the seating 11a, to a plurality of outlet openings (not shown) provided in the nozzle body downstream of the seating 11a. In Figure 1, the valve needle 12 is seated against the seating 11a. The delivery chamber 13 communicates with a supply passage 24 for fuel through which fuel flows towards the delivery chamber 13, in use, as will be described hereinafter.

[0020] The valve needle 12 is biased into engagement with the seating 11a by means of a compression spring 15 located within a spring chamber (not indicated) which is vented through a passage 17 provided in a part of the fuel injector housing to an appropriate low pressure fuel reservoir 18. The end of the valve needle 12 remote from the seating 11a is connected to one end of a load transmitting member 20, the member 20 being connected, at its other end, to a piston member 22. The piston member 22 forms part of a control valve arrangement, referred to generally as 26, the control valve arrangement 26 also including a valve member 28 provided with a through bore 30 within which the piston member 22 is slidable. The piston member 22 includes a lower region 22a of enlarged diameter, an upper region 22b of reduced diameter and an intermediate region 22c which may be of further reduced diameter. The region 22a of the piston member is slidable within a bore 29 provided in the fuel injector housing, the bore 29 being coaxially aligned with the through bore 30 provided in the valve member 28. In use, sliding movement of the piston member 22 is transmitted to the valve needle 12 by means of the load transmitting member 20.

[0021] The valve member 28 is also slidable within a bore 32 provided in a part of the fuel injector housing, the bore 32 being shaped to define first and second annular chambers, 34 and 36 respectively. The first annular chamber 34 communicates with a supply passage 38 for fuel communicating with a source 40 of fuel under high pressure. For example, the source 40 may be the common rail of a common rail fuel system which is charged to a suitably high pressure by a high pressure fuel pump. The second annular chamber 36 communicates with the supply passage 24 which, in turn, communicates with the delivery chamber 13 such that fuel within the annular chamber 36 is able to flow to the nozzle body.

[0022] The valve member 28 is provided with a passage 42, extending diametrically through the valve member 28, which communicates with the annular chamber 34 and a chamber 31 defined by the bore 30 and the intermediate region 22c of the piston member 22. The outer surface of the piston member 22 is shaped to define a seating surface 46, of substantially frusto conical form, with which a surface 44 of the valve member 28 is engageable, the surface 44 also being of substantially frusto conical form.

[0023] In use, as sliding movement of the piston member 22 is transmitted to the valve needle 12, the seating surface 46 provided on the piston member 22 is movable with the valve needle 12.

[0024] The upper region 22b of the piston member 22 is provided with a restricted passage 48 which provides a restricted flow path for fuel between the chamber 31 and a control chamber 50 defined by a part of the bore 32, the upper surface of the valve member 28, the upper surface of the piston region 22b and the lower surface of a distance piece 52 in abutment with the fuel injector housing. The distance piece 52 is provided with a passage 54 which communicates with the control chamber 50.

[0025] The fuel injector arrangement also includes a second control valve arrangement, including a valve member 56 which is engageable with a seating 58, defined by a surface of the distance piece 52, to control communication between the passage 54 and a low pressure fuel reservoir. For example, the low pressure fuel reservoir may be the same low pressure fuel reservoir 18 with which the spring chamber housing the compression spring 15 communicates. Movement of the second valve member 56 away from the seating 58 is controlled by means of an electromagnetic actuator arrangement, referred to generally as 60, such that actuation of the electromagnetic actuator causes the valve member 56 to lift away from the seating 58, thereby permitting fuel within the control chamber 50 to flow, via the passage 54, to low pressure.

[0026] In use, fuel under high pressure is supplied from the source 40, through the passage 38, to the first annular chamber 34, through the passage 42 formed in the valve member 28 and into the chamber 31. Fuel within the chamber 31 is able to flow into the control chamber 50 via the restricted passage 48. With the valve member 56 seated against the seating 58, fuel within the control chamber 50 is unable to flow past the seating 58 to low pressure and, thus, fuel pressure within the control chamber 50 increases. High pressure fuel within the control chamber 50 acts on the upper end surface of the region 22b of the piston member 22 and serves to bias the piston member 22 in a downwards direction. In addition, a downwards force results from a part of the surface 46 being exposed to fuel within the chamber 31. The piston member 22 is biased in a downwards direction by this combined force, the force on the piston member 22 being transmitted to the valve needle 12 so as to seat the tip portion of the valve needle 12 against the seating 11a.

[0027] During this stage of operation, high fuel pressure within the control chamber 50 also acts on the upper end face of the valve member 28 serving to bias the valve member 28 in a downwards direction such that the surface 44 engages the seating surface 46 defined on the piston member 22. Thus, fuel within the annular chamber 34 is unable to flow past the seating surface 46 into the supply passage 24 and into the delivery chamber 13. It will therefore be appreciated that, during this stage of operation, fuel injection does not take place through the outlet openings provided in the nozzle body. The load applied to the piston member 22 by the valve member 28 assists in urging the valve needle 12 into engagement with the seating 11a.

[0028] When fuel injection is to be commenced, the electromagnetic actuator arrangement 60 is actuated such that the valve member 56 is lifted away from the seating 58. Thus, fuel within the control chamber 50 is able to flow, via the passage 54, past the seating 58 to low pressure and fuel pressure within the control chamber 50 reduces, fuel flow to the control chamber 50 being restricted. The fuel pressure within the control chamber 50 will reduce to an amount dependent upon the source pressure, the rate of flow of fuel through the passage 42 and through the restricted passage 48, and the rate of fuel flow through the second control valve arrangement.

[0029] As fuel pressure within the control chamber 50 is reduced, high fuel pressure within the chamber 31 acting on the surface 44 of the valve member 28 will serve to urge the valve member 28 in an upwards direction in the illustration shown. The valve member 28 therefore lifts away from the seating surface 46 defined by the piston member 22 and high pressure fuel within the chamber 31 is able to flow past the seating 46 into the second annular chamber 36, through the supply passage 24 and into the delivery chamber 13.

[0030] As fuel pressure within the delivery chamber 13 increases, the force applied to the thrust surface 12a of the valve needle 12 increases, serving to urge the valve needle 12 in an upwards direction away from the seating 1 la. The effective area of the upper surface of the piston region 22b exposed to fuel pressure within the control chamber 50, the effective area of the seating surface 46 exposed to fuel pressure within the chambers 31 and 36, the spring constant of the spring 15 acting on the valve needle 12 and the effective area of the thrust surface 12a exposed to fuel pressure within the delivery chamber 13 are chosen such that, when the valve member 28 lifts away from the seating surface 46, the upward force applied to the thrust surface 12a is sufficient to overcome the combined downward force transmitted to the valve needle 12. Thus, during this stage of operation, the valve needle 12 lifts away from the seating 11a and fuel is able to flow past the seating 11a through the outlet openings into the engine cylinder or other combustion space. Fuel injection therefore takes place.

[0031] When it is desired to cease fuel injection, the electromagnetic actuator arrangement 60 is de-actuated such that the valve member 56 returns against the seating 58 and fuel within the control chamber 50 is no longer able to escape past the seating 58 to the low pressure fuel reservoir. As high pressure fuel continues to flow into the control chamber 50, high fuel pressure is therefore re-established within the control chamber 50.

[0032] High pressure fuel within the control chamber 50 acts on the valve member 28 and serves to bias the valve member 28 in a downwards direction against the force applied to the surface 44 of the valve member 28. The effective area of the upper end of the valve member 28 exposed to fuel within the control chamber 50 is substantially the same as the effective area of the surface of the valve member 28 exposed to fuel within the annular chamber 36. The fuel pressure within the annular chamber 36 will be slightly lower than that within the control chamber 50 and, thus, the valve member 28 is urged in a downwards direction against the seating surface 46. Fuel within the chamber 31 is therefore no longer able to flow past the seating surface 46 into the delivery

chamber 13 and fuel pressure within the delivery chamber 13 is reduced, thereby reducing the upward force applied to the thrust surface 12a of the valve needle 12. The increased fuel pressure within the control chamber 50 acting on the surfaces of the piston region 22b and the valve member 28, high fuel pressure within the chamber 31 acting on the seating surface 46 and the spring force due to the compression spring 15 act against the reduced, upward force applied to the thrust surface 12a and serve to bias the piston 22 and the valve needle 12 in a downwards direction. The valve needle 12 is therefore returned into engagement with the seating 11 11a and fuel injection through the outlet openings is ceased.

[0033] The fuel injector is advantageous in that the valve needle 12 is forced against its seating 11a to cease fuel injection and does not rely solely on termination of the supply of fuel to the delivery chamber 13. It will be appreciated, therefore, that when the valve member 28 and the valve needle 12 are returned against their respective seatings 46, 11a, a residual amount of low pressure fuel will remain within the supply passage 24, the annular chamber 36 and the delivery chamber 13. This low pressure fuel can be drained to a low pressure fuel reservoir via narrow clearances defined between the upper end of the bore 11 and the adjacent part of the valve needle 12 and between the region 22a of the piston member 22 and the bore 29. Alternatively, or additionally, a restricted passage (not shown) may be provided to drain any residual low pressure fuel to the low pressure fuel reservoir.

[0034] If the valve needle 12 becomes stuck in an open position when it is desired to cease fuel injection, the high pressure fuel re-established in the control chamber 50 will serve to bias the valve member 28 in a downwards direction against the seating surface 46. Thus, high pressure fuel supplied to the chamber 31 is no longer able to flow past the seating 46 into the delivery chamber 13. Thus, even if the valve needle 12 becomes stuck in an open position, fuel injection will eventually cease when residual fuel within the delivery chamber 13, the supply passage 24 and the annular chamber 36 is either injected into the engine cylinder or is drained to low pressure. The fuel injector arrangement therefore prevents fuel injection during an undesirable stage of the fuel injection cycle if the valve needle 12 becomes stuck in an open position. In the event that the valve member 28 becomes stuck in a lifted position, the valve needle 12 is still able to return into engagement with its seating 11a under the action of the fuel pressure within the control chamber 50 and chamber 31. It will be appreciated that continuous injection of fuel from the high pressure source 40 will only occur in the event that both the valve needles 12 and the valve member 28 become stuck in their lifted positions.

[0035] An alternative embodiment of the invention is shown in Figure 2, with the same reference numerals being used to denote similar parts to those shown in Figure 1. In this embodiment, the piston member 22 is of shortened form, including only the region 22a, and the valve member 28 is provided with a bore 30a, defining a chamber 62, which communicates with the passage 42 provided in the valve member 28. The chamber 62 also communicates with a restricted passage 64 provided in the valve member 28, the restricted passage 64 communicating with the control chamber 50. The restricted passage 64 therefore provides the same function as the restricted passage 48 provided in the piston region 22b in the embodiment shown in Figure 1. Operation of this embodiment of the invention is as described hereinbefore, with fuel injection being controlled by actuating and de-actuating the actuator arrangement 60.

[0036] Figure 3 shows a further alternative embodiment of the fuel injector with the same reference numerals being used to denote similar parts to those shown in Figures 1 and 2. In this embodiment of the invention, the valve member 28 is provided with a restricted passage 70 which provides communication between the annular chamber 34 and a control chamber 72, the control chamber 72 being defined, in part, by a bore provided in the distance piece 52. A compression spring 74 is housed within the control chamber 72 which serves to urge the valve member 28 against the seating surface 46 defined by the piston member 22. The piston member 22 is provided with an axially extending passage 80 which communicates with a passage 82, extending diametrically through the piston member 22, the passage 82 communicating with the annular chamber 36 such that, when the valve member 28 is lifted away from the seating 46, fuel is able to flow from the annular chamber 34 into the annular chamber 36 and, thus, to the delivery chamber 13 in the nozzle body.

[0037] Operation of the fuel injector arrangement shown in Figure 3 is achieved in a similar way to operation of the embodiments shown in Figures 1 and 2. Thus, in use, when fuel injection is to be commenced, and with the valve member 56 seated against the seating 58, fuel under high pressure is supplied from the source 40 to the control chamber 72. With the valve member 56 seated against the seating 58, fuel within the control chamber 72 is unable to escape to low pressure such that high pressure fuel within the control chamber 72 acts on the end face of the valve member 28 to urge the valve member 28 in a downwards direction against the seating 46 provided on the piston member 22. The spring 74 within the control chamber 72 also urges the valve member 28 in a downwards direction against the seating 46.

[0038] When fuel injection is to be commenced, the actuator arrangement 60 is actuated such that the valve member 56 moves away from the seating 58, thereby permitting fuel within the control chamber 72 to flow to low pressure. Fuel flow to the control chamber 72 is restricted by the passage 70 and fuel pressure within the control chamber 72 is therefore reduced. The upward force acting on the valve member 28 due to fuel pres-

sure within the annular chamber 34 overcomes the downward force acting on the valve member 28 due to reduced fuel pressure within the control chamber 72 and the force due to the spring 74. The valve member 28 is therefore lifted away from the seating 46, permitting fuel within the annular chamber 34 to flow, via passages 80 and 82, into the annular chamber 36 and subsequently into the delivery chamber 13. High pressure fuel within the delivery chamber 13 acts on the thrust surface 12a and serves to bias the valve needle 12 in an upwards direction away from its seating 11a so that fuel in the delivery chamber 13 can flow past the seating 11a and out through the outlet openings provided in the nozzle body. Fuel injection therefore takes place.

[0039] As described previously, fuel injection ceases when the actuator 60 is de-actuated, re-establishing high fuel pressure within the control chamber 72. In this embodiment of the invention, the compression spring 74 within the control chamber 72 aids downward movement of the valve member 28 against the seating 46 when the valve member 56 is closed against its seating 58. However, it will be appreciated that the compression spring 74 is optional and need not be provided. Thus, in this embodiment of the invention, the control chamber 72 may take the form of the control chamber 50 in Figures 1 and 2. It will further be appreciated that, if desired, a spring equivalent to the spring 74 could be used in the other embodiments described herein.

[0040] Figure 4 is a further alternative embodiment of the invention in which the piston member 22 is provided with a blind bore 88 and a passage 90, extending diametrically through the piston member 22, the passage 90 providing communication between a chamber defined by the bore 88 and the annular chamber 36. The valve member 28 is slidable within the bore 88 and includes an elongate region 28a which extends into the bore 88, the valve member 28a having, at its lower end, a region 28b having a diameter greater than that of the region 28a. The blind end of the bore 88 defines, together with the lower end face of the valve member region 28b, a chamber 92 for fuel which is connected, via a passage 94, to a low pressure fuel reservoir.

[0041] As described for the previous embodiments, fuel injection is controlled by controlling the fuel pressure within the control chamber 50. In this embodiment of the invention, as fuel pressure within the chamber 92 acting on the lower end face of the valve member region 28b is connected to low pressure, when high fuel pressure is re-established in the control chamber 50 to terminate fuel injection, the valve member 28 is returned against the seating 46 on the piston member 22 more rapidly. Thus, fuel injection can be terminated more rapidly.

[0042] It will be appreciated that further alternative embodiments of the invention may include different combinations of the features shown in Figures 1 to 4. For example the compression spring 74 in the control chamber 72 and the chamber 92 connected to low pressure may be employed in any of the embodiments of the invention hereinbefore described.

Claims

1. A fuel injector arrangement comprising a nozzle body provided with a first bore (11) within which a valve needle (12) is slidable, the needle being engageable with a first seating (1 la) to control the flow of fuel from a delivery chamber (13) to an outlet opening, and a control valve arrangement (26) for controlling the supply of fuel to the delivery chamber (13), characterised in that the control valve arrangement (26) includes a valve member (28) which is engageable with a second seating (46) which is moveable with the valve needle (12) to control the supply of fuel to the delivery chamber (13).

2. The fuel injector arrangement as claimed in Claim 1, wherein the second seating (46) is defined by a piston member (22; 22a) which is moveable with the valve needle (12).

3. The fuel injector arrangement as claimed in Claim 2, wherein the piston member (22; 22a) and the valve needle (12) are integrally formed.

4. The fuel injector arrangement as claimed in Claim 2, wherein the piston member (22; 22a) and the valve needle (12) are separate parts interconnected by means of a load transmitting member (20).

5. The fuel injector as claimed in Claim 3 or Claim 4, wherein the piston member (22) is slidable within a further bore (30) provided in the valve member (28).

6. The fuel injector as claimed in Claim 3 or Claim 4, wherein the valve member (28) is slidable within an additional bore (88) provided in the piston member (22).

7. The fuel injector arrangement as claimed in any of Claims 2 to 6, wherein a surface of at least one of the valve member (28) and the piston member (22; 22a) is exposed to fuel pressure within a first control chamber (50; 72), fuel pressure within the first control chamber (50; 72) being controlled, in use, to control movement of the valve needle (12).

8. The fuel injector arrangement as claimed in Claim 7, comprising a further control valve arrangement (56, 58) for controlling fuel pressure within the first control chamber (50; 72).

9. The fuel injector arrangement as claimed in Claim 7 or Claim 8, further comprising a second control chamber (92) for fuel, fuel pressure within the sec-

ond control chamber (92) acting on a further surface associated with the valve member (28) so as to oppose the force due to fuel pressure within the first control chamber (50; 72).

10. The fuel injector arrangement as claimed in Claim 9, wherein piston member (22) is provided with a blind bore (88), the valve member (28) being slidable within the blind bore (88), wherein the second control chamber (92) is defined, in part, by the blind end of the bore (88).

11. The fuel injector arrangement as claimed in any of Claims 7 to 10, wherein the first control chamber is provided with biasing means (74) which serve to bias the valve member (28) against the second seating (46).

12. The fuel injector arrangement as claimed in any of Claims 7 to 11, wherein the valve member (28) is provided with a restricted passage (64; 70) through which fuel is supplied to the first control chamber (50; 72), in use.

13. The fuel injector arrangement as claimed in any of Claims 7 to 11, wherein the piston member (22; 22a) is provided with a restricted passage (48) through which fuel is supplied to the first control chamber (50), in use.

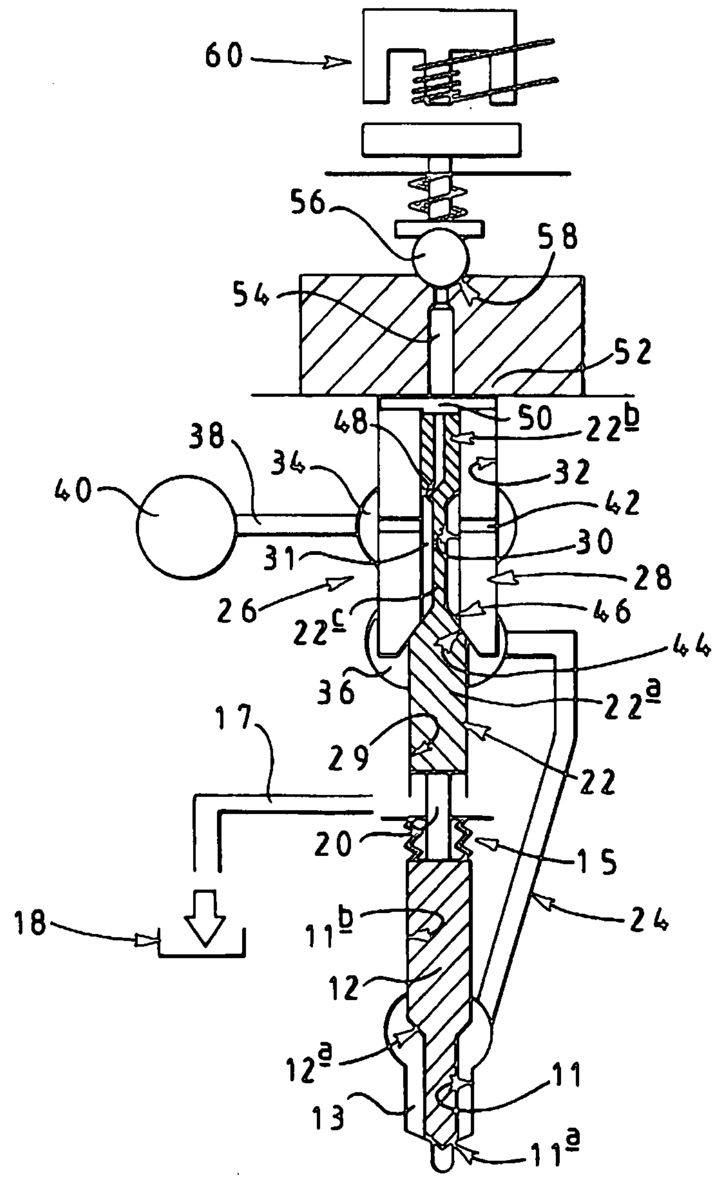
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FIG 1

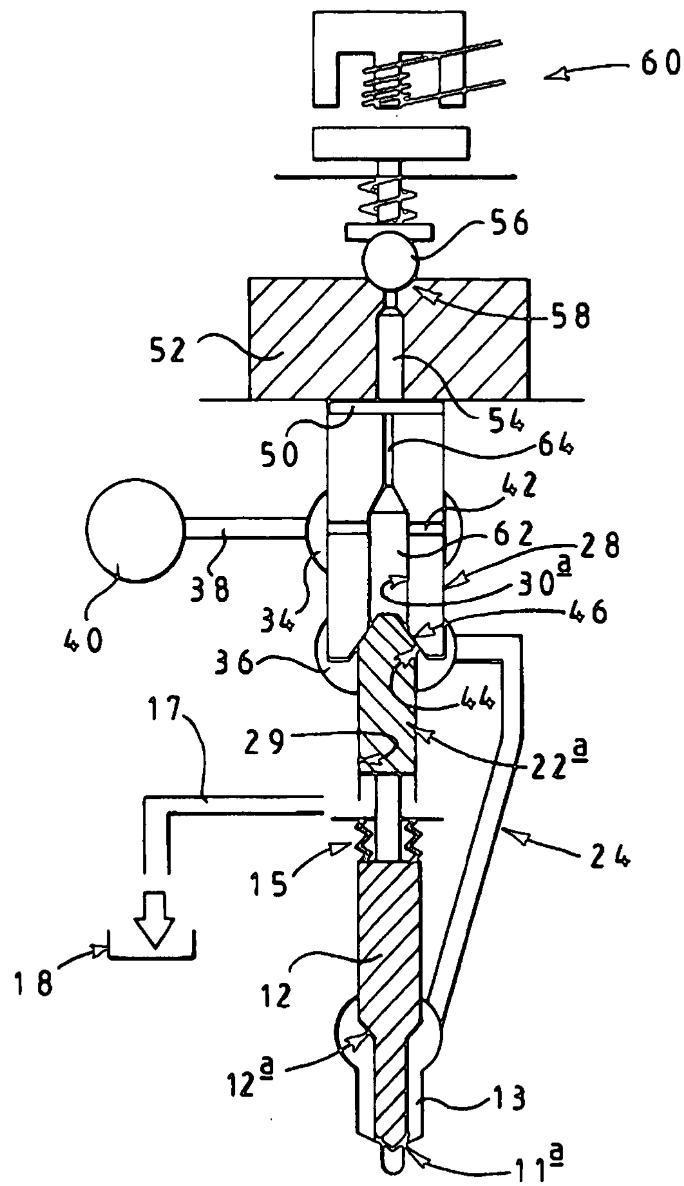
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FIG 2

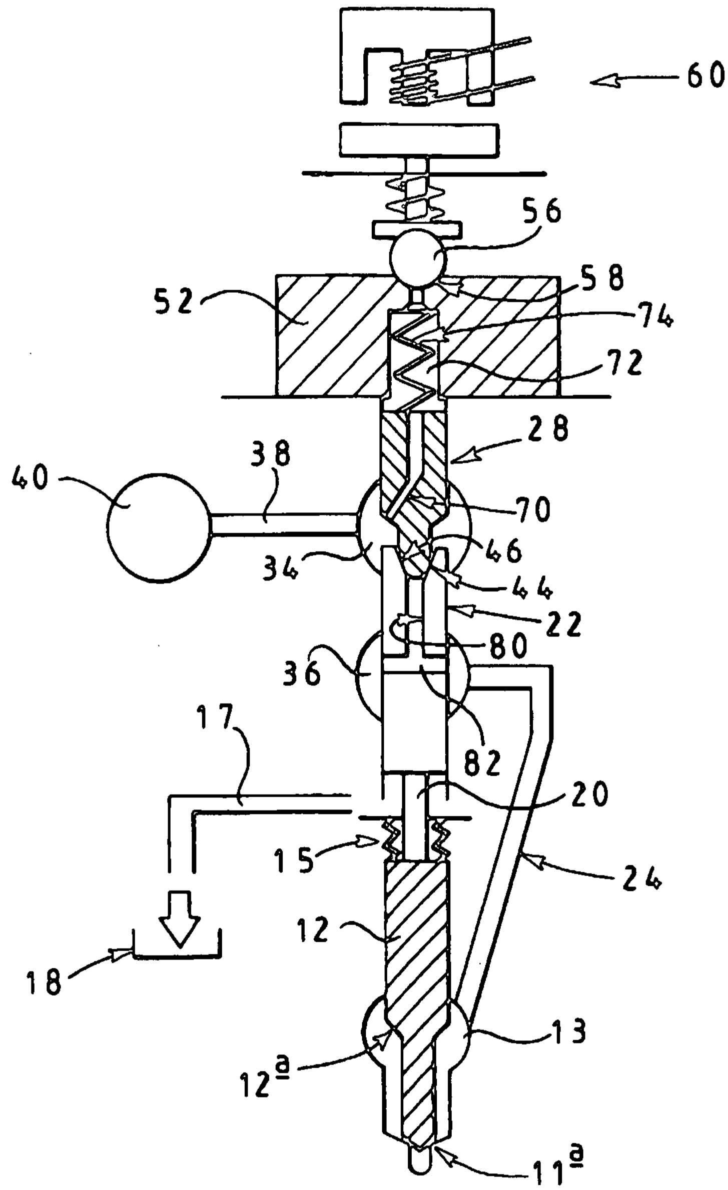
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FIG 3

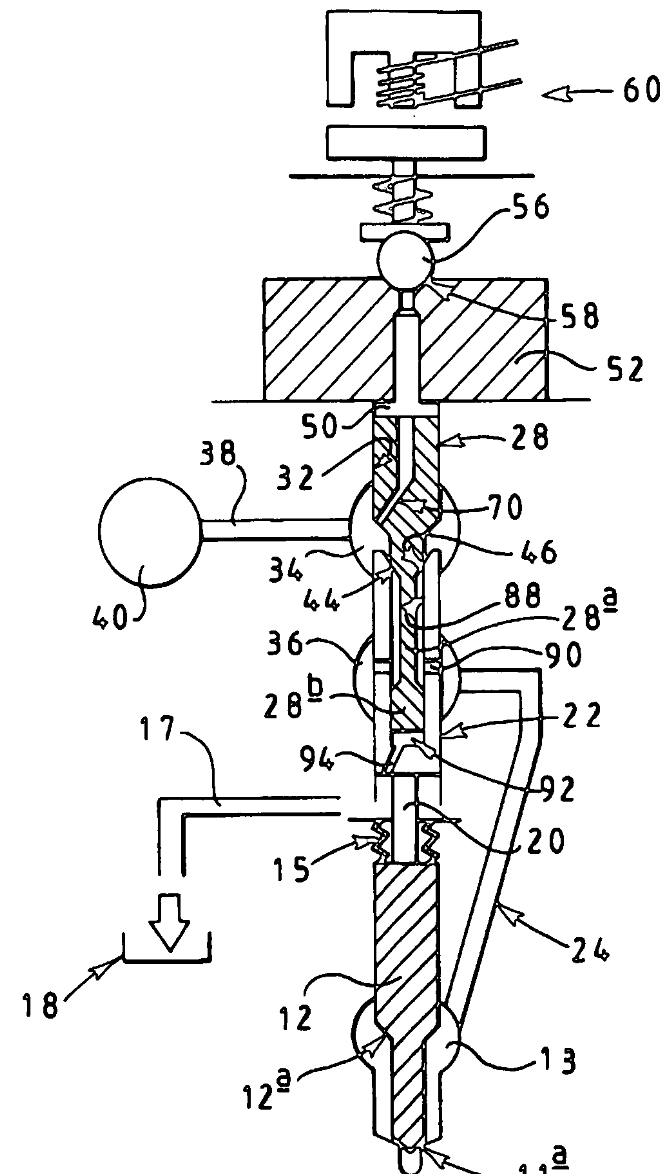
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FIG 4